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Abstract: Objective: It has been reported that surgical treatment for prosthetic valve endocarditis complicated with destruction of the aortic annulus is associated with high mortality and morbidity. We use a relatively simple procedure consisting of a patch plasty of the abscess cavity, in addition to complete removal of the infected tissue of the abscess cavity followed by a standard aortic valve replacement.

Methods: Between October 2003 and April 2009, 8 patients (7 males; mean age, 68.6 ± 9.8 years) with prosthetic valve endocarditis complicated with destruction of the aortic annulus were surgically treated at Tominaga hospital. All patients were in New York Heart Association functional class III or IV. All patients had active endocarditis. Preoperative echocardiography revealed that 4 patients had moderate or severe aortic regurgitation, and 2 patients had mitral valve endocarditis as well.

Results: There were no operative deaths (≤30 days). Cardiac complications included paroxysmal atrial fibrillation in 3 patients and transient atrioventricular block in one. One patient died of multiple organ failure 66 days after the surgery. The overall in-hospital mortality was 12.5%. Patients were followed-up for 6 to 49 months (mean, 31±19 months). There was no recurrent prosthetic valve endocarditis. One patient required reoperation (mitral annuloplasty and redo aortic valve replacement) mainly due to severe functional mitral regurgitation. There were 2 late deaths: lung cancer in 1 and multiple organ failure related to pneumonia after the aforementioned redo operation.

Conclusion: Our simple procedure for complicated prosthetic valve endocarditis yielded excellent early and mid-term outcomes.

Treatment of Prosthetic Valve Endocarditis Complicated with Destruction of the Aortic Annulus

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Abstract

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Methods: Between October 2003 and April 2009, 8 patients (7 males; mean age, 68.6 $\pm$ 9.8 years) with prosthetic valve endocarditis complicated with destruction of the aortic annulus were surgically treated at our hospital. All patients were in New York Heart Association functional class III or IV. All patients had active endocarditis. Preoperative echocardiography revealed that 4 patients had moderate or severe aortic regurgitation, and 2 patients had mitral valve endocarditis as well.

Results: There were no operative deaths ($\leq$30 days). Cardiac complications included paroxysmal atrial fibrillation in 3 patients and transient atrioventricular block in one. One patient died of multiple organ failure 66 days after the surgery. The overall in-hospital mortality was 12.5%. Patients were followed-up for 6 to 49 months (mean, 31$\pm$19 months). There was no recurrent prosthetic valve endocarditis. One patient required reoperation (mitral annuloplasty and redo aortic valve replacement) mainly due to severe functional mitral regurgitation. There were 2 late deaths: lung cancer in 1 and multiple organ failure related to pneumonia after the aforementioned redo operation.

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Introduction

Prosthetic valve endocarditis (PVE) is a serious complication that can follow aortic valve replacement, and severe PVE often destroys the aortic annulus, leading to "aorto-left ventricular discontinuity." Periannular abscesses occur in a significant number of PVE patients, occurring in 56% to 100% of affected patients.[1,2] Moreover, when destruction of the aortic annulus is present in patients with PVE, hemodynamic instability can easily occur as a result of the uncontrollable septic state associated with abscess formation, perivalvular leakage, prosthetic valve malfunction or conduction disturbances. These patients require complex surgical interventions in addition to aggressive antibiotic therapy.[1,2] Therefore, multiple surgical techniques have been proposed for complex reconstruction to improve mortality and morbidity in PVE patients with destruction of the aortic annulus.

Previous studies have reported good outcomes with aortic root replacement using homografts, which are thought to be more resistant to bacterial or fungal infections than prosthetic valves.[3-9] In Japan, the supply of homografts is very limited, and as an alternative approach, the Ross procedure has been performed in some institutions with excellent results.[9] However, the Ross procedure is technically demanding and requires longer cross-clamp time and cardiopulmonary bypass time, potentially increasing mortality and morbidity.

Since 2003, we have performed a relatively simple procedure for PVE complicated with destruction of the aortic annulus. Our technique includes patch reconstruction of the aortic annulus followed by placement of a new prosthetic valve in addition to aggressive removal of the infected tissue and drainage of the abscess cavity.

The aim of this study was to evaluate the efficacy of our surgical strategy for PVE complicated with destruction of the aortic annulus.

Patients and Methods

Patients

Between October 2003 and April 2009, 8 patients were admitted to Tominaga hospital with a diagnosis of PVE complicated with destruction of the aortic annulus. These patients formed the cohort for this study. In all of these patients, diagnosis was made based on the Duke criteria.[1,10]

The patient demographics and clinical characteristics are summarized in Table 1. The mean age was 68.6 ± 9.8 years (range, 53 to 84 years) and 7 patients were male. All patients were in New York Heart Association (NYHA) functional class III or IV and had active infection. The median interval between the initial and the redo operation was 5.5 ±6.1 months (range of 1.9 to 20.3 months). In terms of the onset of infection[11], there was 1 case of early PVE (onset within two months of the initial operation) and 7 cases of late PVE (onset more than 2 months after the initial operation). Two patients had had dental treatment within 1 month prior to the onset of the PVE episode.

For the initial aortic valve replacement (AVR), isolated AVR was performed in 4 patients and AVR with additional surgical procedures was performed in 4 (Table 1). A permanent pacemaker was implanted in patient 7 due to sick sinus syndrome and patient 8 had a minor stroke after the operation, while the other patients had no postoperative complications.

In terms of infectious agents, the microorganisms causing PVE were methicillin-resistant *Staphylococcus epidermidis* (MRSE) in 5 patients, methicillin-sensitive *Staphylococcus epidermidis* (MSSE) in 1, and unknown in 2.

The preoperative echocardiographic data are shown in Table 1. Left ventricular function was relatively preserved in this cohort, with a mean left ventricular ejection fraction (LVEF) of 57 ± 18%, although 2 patients had significantly depressed LVEF (25% and 35%). Visible vegetation on the aortic prosthesis was usually identified by either transthoracic or transesophageal echocardiography. Perivalvular leakage was common, with moderate or severe aortic regurgitation (AR) in 4 patients. Pressure gradients across the prosthetic valve were commonly elevated because of restricted mobility of leaflets and obstruction of left ventricular outflow due to the presence of abscesses formation. Two patients were found to have vegetation on the mitral valve as well.

Indications for surgery were advancing congestive heart failure in 1 patient and uncontrollable infection despite aggressive antibiotic treatment in 7.

Surgical Technique

Surgery was performed via median sternotomy with the use of extracorporeal circulation and mild systemic hypothermia. Myocardial protection was accomplished by antegrade and, if feasible, retrograde cold blood cardioplegia. The left ventricle was vented by cannulation through the right superior pulmonary vein.

Our surgical strategy for PVE complicated with destruction of the aortic annulus consisted of radical debridement (complete removal of infected or necrotic tissue with a curette) and irrigation of the abscess cavity with large amount of saline solution. Most times, patch reconstruction of the left ventricular outflow tract at the level of and below the aortic annulus was required using equine pericardium with a 5-0 polypropylene running suture, and fibrin glue mixed with antibiotics (vancomycin or gentamicin) was injected into the cavity. When the aortic annulus was reconstructed, AVR was performed with pledgeted mattress sutures passed through both the patch and the aortic wall to securely anchor the prosthetic valve to the reconstructed aortic annulus. Sometimes, the sutures were passed from outside the aortic wall to pass through enough tissue to stabilize the prosthesis. Postoperatively, sufficient antibiotics were administered intravenously for at least 4 to 6 weeks, and then oral antibiotics were given for at least several months.

Results

Operative and Early Postoperative Results

The operative results are shown in Table 2. There were no intraoperative nor operative deaths (<30 days). As shown in Figure 1, abscess cavities were found in the entire aortic annulus in 4 patients (this was classified as "aorto-left ventricular discontinuity"). None of these patients had any abscess formation beyond the sinus of Valsalva or near the coronary ostia. In 2 patients, direct closure of the cavity was feasible because the abscess cavity was small (only a 3-5mm gap was identified). AVR was performed using biological valves in 4 patients and mechanical valves in 4. Patient 6 had vegetation on both aortic and mitral prostheses, which necessitated redo mitral valve replacement using the standard technique. In patient 7, we removed vegetation attached to the native mitral valve in addition to AVR.

All patients were successfully weaned from cardiopulmonary bypass, but 3 patients required an intra-aortic balloon pump to achieve hemodynamic stability. The mean cardiopulmonary bypass time was 213±82 minutes (range, 112 to 367 minutes), and the mean aortic cross clamp time was 145±45 minutes (range, 86 to 232 minutes). All the patients left the operation room without significant aortic regurgitation (AR; defined as mild or less).

As shown in Table 2, patient 8 developed multiple complications, including general prostration caused by infectious colitis, renal dysfunction and pneumonia, and eventually died of multiple organ failure 66 days after the operation. The overall in-hospital mortality rate was 12.5%. The median postoperative respiratory support time was 27 hours (range, 12 to 184 hours) and the mean hospital stay, excluding the one of hospital death, was 65±22 days (range, 34 to 92 days). During the hospital stays, 3 patients developed paroxysmal atrial fibrillation and 1 patient developed transient atrioventricular block which did not required permanent pacemaker implantation. Patient 6 required sternal wound re-exploration for postoperative bleeding. Patient 7 had refractory gastrointestinal bleeding and also required prolonged respiratory support. No patients had recurrent infection on prosthetic valves or sepsis. Echocardiographic examination on discharge revealed that two patients had developed moderate AR.

Mid-Term Follow-up Results

Patients were followed up for 6 to 49 months, with a mean of 31±19 months. Patient 1 was lost to follow-up at 8 months after surgery. Patient 2 required re-operation (mitral annuloplasty and redo AVR) mainly due to severe functional MR 32 months after the previous redo AVR. This was essentially associated with poor left ventricular function and a dilated left ventricle. Repeat AVR was also performed because this patient had moderate AR due to perivalvular leakage. Of note, there was no evidence of recurrent infection around the aortic root. This patient died of multiple organ failure related to refractory pneumonia 3 months later. Patient 6 died of lung cancer 6 months after the operation.

Follow-up echocardiography demonstrated that 2 patients had moderate AR without hemodynamic instability. Four patients continue to be followed up at our institution and are in NYHA functional class I or II with no signs of recurrent PVE.

Discussion

PVE complicated with destruction of the aortic annulus is a potentially fatal complication of AVR. The surgical treatment of this condition is challenging, with operative mortality rates ranging from 7.3% to 33%.[1,2,12-14] This high mortality is associated with preoperative hemodynamic deterioration due to uncontrolled sepsis from abscess formation, valve malfunction, multiple organ involvement due to severe infection and low cardiac output, and the complexity of the surgical procedure.[1,2] Because the surgical mortality rate of the third redo operation for recurrent PVE can be as high as 55.6%,[15] it is very important to choose a surgical strategy that decreases the recurrence of PVE.

The surgical management of PVE complicated with an aortic annular abscess involves aggressive and complete debridement of all infected or necrotic tissue, reconstruction of the damaged annulus and restoration of valve function. Many authors have reported that extended debridement and resection of infected paravalvular tissue are more important than the materials used for the reconstruction of the aortic valve.[7,17,18,20,21] Despite the fact that aggressive debridement may cause complete heart block requiring permanent pacemaker implantation, debridement of all infected tissue remains the first priority.

One way to minimize the risk of recurrent PVE may be the injection of fibrin glue mixed with antibiotics into the abscess cavity. We employed this technique whenever we performed patch reconstruction of the aortic annulus, because antibiotics mixed with fibrin glue are thought to be delivered continuously into the surrounding tissue for the first few days following surgery.[16] There was no recurrence of PVE in our series, although this does not conclusively prove the effectiveness of this technique.

Other surgical techniques that have been used in the past include valve replacement with patch closure of the abscess cavity,[17-19] aortic root replacement using a homograft,[3-7] autograft (the Ross procedure),[8,9] composite-valve conduit,[20,21] Freestyle stentless bioprosthesis,[13,22] and translocation of the aortic valve with saphenous vein bypass grafts to the coronary arteries.[23,24]

It is well known that both homografts and autografts offer excellent hemodynamic performance and it is thought that they are resistant to infection. Indeed, the reported incidence of recurrent PVE after aortic root replacement using homografts or autografts range from 0% to 4.2% and 0% to 4%, respectively.[3-9] However, persistent infection and false aneurysms or valve degeneration requiring reoperation can occur even after aortic root replacement using a homograft.[18,25] Furthermore, the Ross procedure is technically demanding and increases aortic cross-clamp time and cardiopulmonary bypass time, and valve dysfunction can occur in both neo aortic valves (in the case of homografts) and neo pulmonary valve (in the case of homografts or other prostheses).[9] Also, the longevity of homografts (either for AVR or for PVR in the Ross procedure) remains unclear, and younger patients may require reoperation at a later date due to structural valve deterioration. Repeat operation in patients with homografts can be very challenging because homografts tend to become heavily calcified.[26]

In Japan, the most important consideration is the relative scarcity of usable homografts, particularly for emergent or urgent situations. This is the reason we designed a relatively simple procedure that consists of reconstruction of the aortic annulus using equine pericardium followed by AVR in patients with PVE complicated with destruction of the aortic annulus. David et al. reported that there were no recurrent infections after AVR and patch plasty in patients with PVE and aortic root abscesses,[17] and Lytle et al. and d'Udekem et al. reported that standard AVR with pericardial patch reconstruction for PVE was not inferior to aortic root replacement using a homograft.[18,19] Although we did not compare our procedure with any other surgical interventions, there were no cardiac-related deaths during hospitalization following our procedure. Moreover, since there was no recurrence of PVE during the mid-term follow-up period in our study, the recurrence rate may not be affected by the choice of the materials used for valve prostheses. Hagl et al. reported that the surgical outcome of aortic root replacement with a composite graft was superior to that of a homograft for PVE[20], and Leyh et al. reported that the outcome of aortic root replacement using a composite graft was not inferior to that of a homograft.[21] Moreover, several authors have recently reported good outcomes for AVR in patients with PVE and aortic root abscess using a Freestyle stentless valve.[9,13,22] Since the handling qualities and performance of a Freestyle valve are similar to those of a homograft, they recommend the use of a Freestyle valve.[13,22] A composite graft or Freestyle stentless valve can serve as a good alternative to a homograft for aortic root replacement. However, because prosthetic valve infection does not usually extend to the sinus of Valsalva or coronary ostium in most patients with PVE complicated with aortic root abscess,[2-9,12-15,17-25] we do not believe that aortic root replacement is always necessary.

Another technical issue to consider is where to anchor the prosthetic valve on the fragile annulus for stability. We anchored the valve with mattress sutures that were passed through both the patch and the aortic wall whenever we performed patch plasty of the aortic annulus. There were no postoperative complications due to valve dehiscence. Also, in early or mid-term follow-up, there were no re-reoperations, excluding one case who underwent mitral annuloplasty and redo AVR mainly due to severe functional mitral regurgitation.

Conclusion

Patients with PVE complicated with an aortic root abscess can be treated safely with patch reconstruction of the aortic annulus and AVR. The early and mid-term outcomes are satisfactory without any recurrence of endocarditis.

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Figure legend

Figure 1: Schemas of abscess cavity site (black shading)

LCA: left coronary artery ostium; NCC: non coronary cusp; RCA: right coronary artery ostium

Table1

Table 1. Patients Demographics and Preoperative Echocardiographic Data (n=8)

No	Gender	Age	NYHA	Previous Operation	Cultures	LVEF (%)	AR Grade	Mitral valve endocarditis	Indication for operation
1	M	68	IV	AVR (Mosaic23), CABG	Unknown	25	III	No	Worsening CHF
2	M	76	III	AVR (CEP23)	MRSE	74	III	No	Uncontrollable infection
3	M	74	III	AVR (CEP23)	MRSE	70	I	No	Uncontrollable infection
4	M	53	III	AVR (CEP27)	MSSE	59	I	No	Uncontrollable infection, peripheral emboli
5	M	63	III	AVR (CEP25), CABG	MRSE	56	IV	No	Uncontrollable infection, severe AR
6	M	60	IV	AVR (SJM23), MVR (CM31), TAP, MAZE	MRSE	65	III	Yes	Uncontrolable infection
7	M	71	IV	AVR(CEP25), MAP, TAP, MAZE	MRSE	35	I	Yes	Uncontrollable infection
8	F	84	IV	AVR (Magna19)	Unknown	68	II	No	Uncontrollable infection

AR: aortic regurgitation; AVR: aortic valve replacement; CABG: coronary artery bypass grafting; CEP: Carpentier-Edwards Pericardial; CHF: congestive heart failure; CM: CarboMedics; LVEF: left ventricular ejection fraction; MAP: mitral annloplasty; MRSE: methicillin-resistant *Staphylococcus epidermidis*; MSSE: methicillin-sensitive *Staphylococcus epidermidis*; MVR: mitral valve replacement; NYHA: New York Heart Association; TAP; tricuspid annuloplasty

Table2

Table 2. Operative and Postoperative Results (n=8)

No	IABP	Aorto-LV discontinuity	Valve	Annulus Reconstruction	Combined Procedure	Complications	Follow up	Recurrent PVE
1	Yes	No	Mosaic 23	Direct	Graft replacement of ascending aorta	AF	8 months	No
2	No	Yes	CEP 21	Patch			32 months	No
3	No	No	CEP 21	Direct			49 months	No
4	No	Yes	CM 25	Patch		Transient AV block	48 months	No
5	No	Yes	CM 21	Patch			45 months	No
6	Yes	Yes	CM 21	Patch	MVR, CABG (LAD)	Reexploration for bleeding, AF, pneumonia	6 months	No
7	Yes	No	CEP23	Patch	Removal of vegetation from MV	Gastrointestinal bleeding, prolonged respiratory support	30 months	No
8	No	No	SJM17	Patch		AF, renal failure, pneumonia, tracheostomy	Died on POD 66	No

AF: atrial fibrillation; AV: artioventricular; CABG: coronary artery bypass grafting; CEP: Carpentier-Edwards Pericardial tissue prosthesis; CM: CardoMedics mechanical prosthesis; LAD: left anterior descending artery; MV: mitral valve; MVR: mitral valve replacement; PVE: prosthetic valve endocarditis; SJM: St Jude Medical mechanical valve

Figure

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